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Timber Harvesting Trends in the Lake States, 1983-1987

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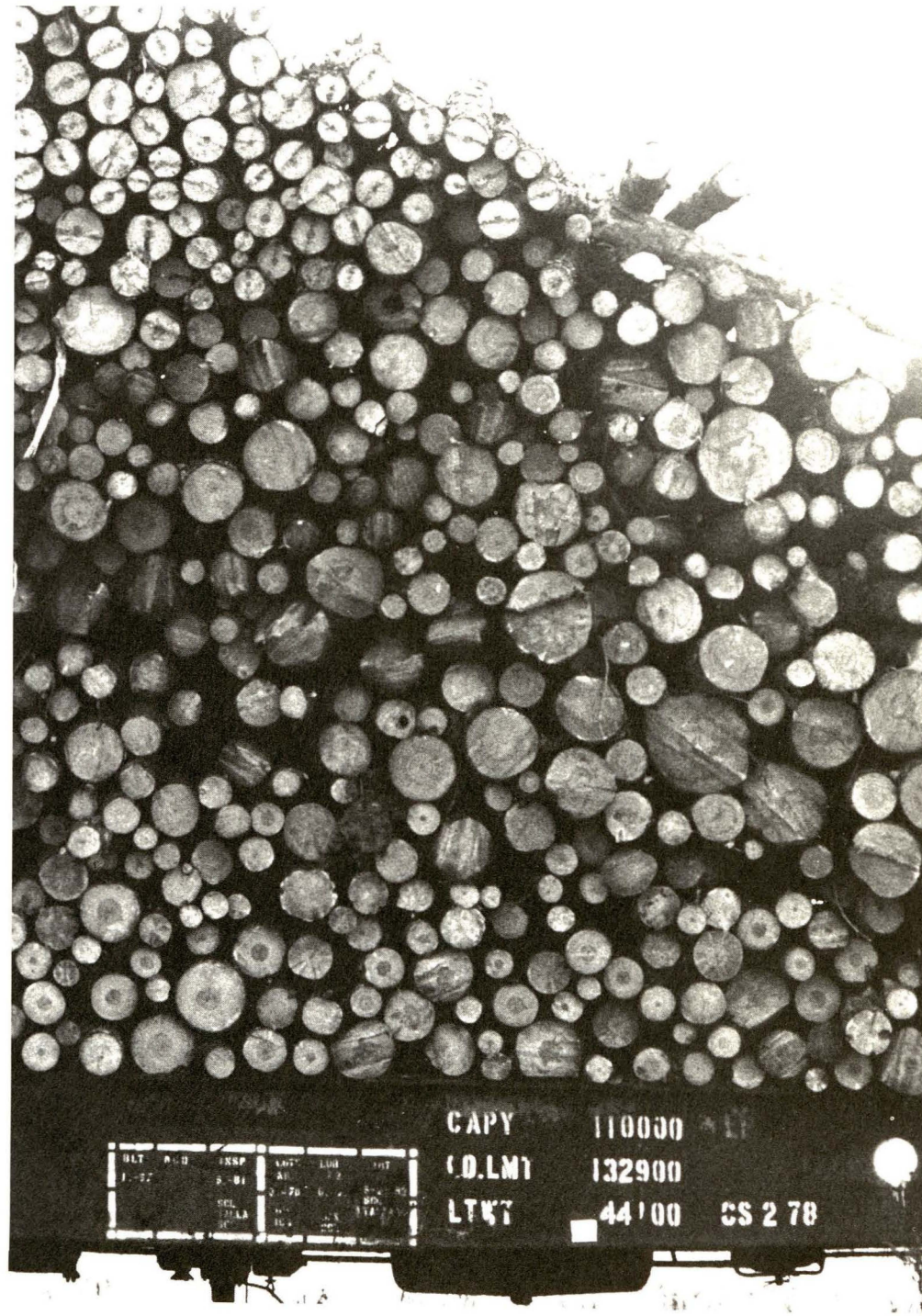

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Foreword

Forest Inventory and Analysis (FIA) is a continuing endeavor mandated by the Forest and Rangeland Renewable Resources Planning Act of 1974, which was preceded by the McSweeney-McNary Forest Research Act of 1928. The objective of FIA is to periodically inventory the Nation's forest land to determine its extent, condition, and volume of timber, growth, and depletions. Up-to-date resource information is essential for framing intelligent forest policies and programs. USDA Forest Service regional experiment stations are responsible for conducting these inventories and publishing summary reports for individual States. The North Central Forest Experiment Station is responsible for forest Inventory and Analysis work in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin.

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Timber Harvesting Trends in the Lake States, 1983-1987

W. Brad Smith and James E. Blyth

Forest industry in the Lake States region has expanded dramatically since the mid-1970's. Removals from growing stock for products in the region are up 12 percent since 1983 and up 72 percent since 1975. The construction of mills using new pulp and board technology and the expansion of existing mills have revitalized the forest economy. As the demand for forest products increases and the resulting pressure on the forest resource grows, more and more timely information is needed on the quantity of growing stock (see Definitions) being removed from the forest and its relation to the standing inventory and emerging timber markets.

The Forest Inventory and Analysis (FIA) research work unit at the North Central Forest Experiment Station has been working to develop methods for estimating growing-stock removals on an annual basis. This information is critical to the Lake States whose 45.7 million acres of timberland represents nearly 10 percent of all timberland in the Nation (USDA Forest Service 1988a). Timberland is spread fairly uniformly across the Lake States with 13.6 million acres in Minnesota, 14.7 million acres in Wisconsin, and 17.4 million acres in Michigan. Growing-stock removals from these lands can be generally classed as (1) Growing stock removed from timberland for products, (2) growing stock removed from timberland and not utilized, and (3) growing stock no longer available for harvest because of a land use change. The third category includes areas set aside as wilderness, county parks, etc. ***This report will focus only on growing-stock removals from timberland for primary products.*** Other growing-stock removals are currently estimated at less than 10 percent of all growing-stock removals in each of the Lake States.

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METHODS

FIA conducts an annual canvass of all woodpulp mills in the region to determine the volume and source of timber processed for pulp. Similar studies are conducted periodically to estimate production of other products. We used the following studies in developing estimates of growing-stock removals for products presented in this report:

Year	Type of study	Citation
MINNESOTA		
1975	All primary products	Blyth *et al.* 1980
1975	Residential fuelwood	Blyth and Wilhelm 1980
1976	Timber utilization	Blyth and Smith 1980
1977	Field inventory	Jakes 1980
1980	All primary products	(unpublished)
1980	Veneer production	Blyth and Smith 1984
1983	Pulpwood production	Blyth and Smith 1985
1984	Pulpwood production	Blyth and Smith 1986a
1984	Veneer production	Blyth and Smith 1986b
1985	Pulpwood production	Blyth and Smith 1987
1985	All primary products	(unpublished MN DNR data)
1986	Pulpwood production	Blyth and Smith 1988a
1987	Pulpwood production	Blyth and Smith 1988b
1987	Inventory update	Hahn and Smith 1987
WISCONSIN		
1975	All primary products	Blyth *et al.* 1980
1981	Fuelwood production	Blyth *et al.* 1984
1981	Timber utilization	(unpublished)
1980	All primary products	(unpublished)
1980	Veneer production	Blyth and Smith 1984
1983	Field inventory	Spencer *et al.* 1988
1983	Pulpwood production	Blyth and Smith 1985
1984	Pulpwood production	Blyth and Smith 1986a
1984	Veneer production	Blyth and Smith 1986b
1985	Pulpwood production	Blyth and Smith 1987
1986	All primary products	(in preparation)
1986	Pulpwood production	Blyth and Smith 1988a
1987	Pulpwood production	Blyth and Smith 1988b
1987	Inventory update	Smith and Hahn 1988
MICHIGAN		
1975	All primary products	Blyth *et al.* 1980
1977	All primary products	Blyth *et al.* 1981
1978	Timber utilization	(unpublished)
1978	All primary products	Blyth *et al.* 1982
1980	All primary products	(unpublished)
1980	Veneer production	Blyth and Smith 1984
1981	Field inventory	Raile and Smith 1983
1983	Pulpwood production	Blyth and Smith 1985
1984	Pulpwood production	Blyth and Smith 1986a
1984	Veneer production	Blyth and Smith 1986b
1984	All primary products	Blyth *et al.* 1988
1985	Pulpwood production	Blyth and Smith 1987
1986	Fuelwood production	(in preparation)
1986	All primary products	(in preparation)
1986	Pulpwood production	Blyth and Smith 1988a
1987	Pulpwood production	Blyth and Smith 1988b
1987	Inventory update	Smith and Hahn 1987

Logging utilization studies are generally conducted at the time of each field inventory. These studies are conducted at active logging operations in each State, and sample trees are tallied to both FIA field standards and according to how the tree will be bucked and used. Survey crews measure every section of the tree bole from the ground up and then record length and diameter at the end of each section. Each section is then classified as used for a specific product or as logging residue. Each section of sawtimber and poletimber boles is further classified as growing stock or nongrowing stock. All limbwood used for products is measured and recorded. Unused limbwood is estimated by subtracting the volume of all bolewood and used limbwood from total tree volume estimated from biomass equations. These data allow us to derive factors to estimate how much growing stock has been removed from timberland to produce the reported primary products.

Most primary products come from growing stock on timberland. However, because of differences in utilization and harvesting practice, the rate of growing stock removed per unit of product produced differs. For example, the following tabulation shows the average amount of growing stock removed to produce 100 cubic feet of primary product receipts for red pine and aspen in the Lake States.

	Growing stock removed per 100 cubic feet of product receipts	
Product	**Red pine**	**Aspen**
Pulpwood	91	94
Saw logs & misc.	102	106
Fuelwood	53	24

On the average it takes 94 cubic feet of aspen growing stock to produce 100 cubic feet of pulpwood receipts. In other words, 6 cubic feet of the aspen required to produce 100 cubic feet of receipts came from nongrowing stock sources such as upper stems, limbwood, stumps, or salvable dead trees. As utilization technology continues to improve, even more product will be derived from nongrowing stock sources.

Saw logs and miscellaneous products, on the other hand, frequently require more than 100 cubic feet of growing stock to produce 100 cubic feet of product receipts. Harvesting for these products often leaves small amounts of growing stock in the woods that is not used for other products. Unlike pulpwood, saw log utilization is perhaps more a factor of the economy than of technology. When markets are strong, more growing stock goes into products. When markets are weak, more growing stock is left in the woods, particularly where alternative markets are lacking. Because utilization factors are compiled for a specific year, we do not know the impact of the annual economy on saw log utilization. Due to the dominance of pulpwood in the Lake States market, however, even a swing of 20 percent in saw log utilization would only produce a 6-percent change in total growing stock removals for the region. Although this is not a significant discrepancy for the Lake States, it would certainly be a consideration where saw logs were the dominant product.

Fuelwood is a product that typically comes from nongrowing stock sources such as dead trees, limbs, upper stems, and logging waste. Harvesting from nontimberland such as fencerows, pastureland, and urban areas also adds heavily to the production of fuelwood. The apparently large proportion of red pine taken from growing stock for fuelwood indicated in our tabulation should be interpreted carefully. Softwood roundwood, although generally not preferred for fuelwood, is being consumed in Michigan in large quantities for industrial boiler fuel. Less than 10 percent of the of red pine fuelwood produced in Wisconsin and Minnesota comes from growing stock sources.

In preparing this report, we compiled factors such as those presented in the tabulation above for each State, product group, and species group in the Lake States (see tables 7-9). FIA production studies linked to these utilization factors have allowed us to accurately report annual removals of growing stock from timberland in the Lake States. Data for products and years when no studies were conducted were estimated by linear interpolation and/or extrapolation. Additional fuelwood data were obtained from estimates provided for the 1980 RPA Assessment (USDA Forest Service 1982). The most recent field inventories for each State have been updated to 1987 by using the STEMS growth model

(Belcher 1981) and by accounting for removals derived by methods described in this report. These updates were the basis of Lake States removals data reported in the 1990 RPA Assessment.

DISCUSSION

Growing-stock removals have increased 12 percent in the Lake States since 1983; Michigan showed the largest increase at 18 percent, followed by Wisconsin (up 11 percent) and Minnesota (up 6 percent). Wisconsin maintains the highest average annual removals per acre of timberland at 21 cubic feet (fig. 1), followed by Michigan (19 cubic feet) and Minnesota (16 cubic feet).

Michigan Markets Strong

Markets for all softwoods except white pine and hemlock have been strong since 1983; all softwoods combined posted an average gain in removals of 5 percent per year. A large increase in red pine markets can be attributed to the recent introduction of "chip-and-saw" technology (Graff 1987) in Michigan (fig. 2a,b). Recent expansion of the Georgia Pacific facility at Gaylord has provided added capacity that should continue to improve future markets for softwoods and low- to medium-density hardwoods.

Although aspen markets in Michigan have been flat in recent years, virtually all other hardwood species posted solid gains. The average increase

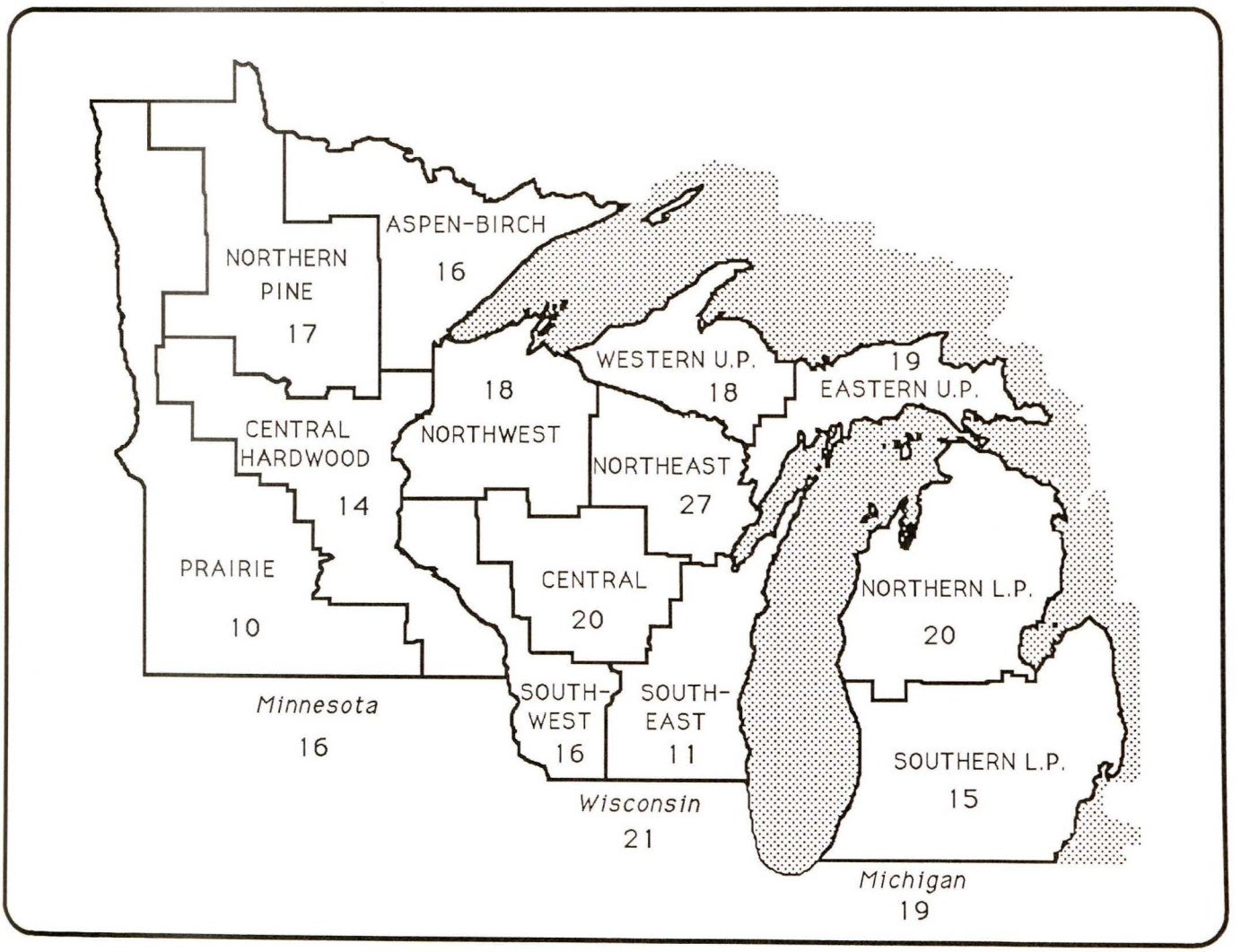

Figure 1.--*Average annual cubic foot growing-stock removals for products per acre of timberland by Survey Unit and State, 1987.*

in removals for non-aspen species was roughly 5 percent per year. Much of this increase may be attributed to strong markets for oak lumber along with hardwood pulp and board products, particularly those that do not use aspen (fig. 2c,d). Aspen markets are expected to show significant gains in Michigan and Wisconsin as the impact of the new Louisiana Pacific mill at Sagola is felt.

Wisconsin Markets Mixed

Softwood markets in Wisconsin have been uneven with red and jack pine removals rising 4 to 5 percent per year while white pine removals are down 11 percent since 1983. Spruce removals have been steady, but all other softwood species have declined dramatically with an overall loss of 35 percent since 1983. Much of this decline can be attributed to a continuing shift of pulping technology that favors hardwoods. Capacity of softwood-oriented sulfite mills has declined 60 percent in Wisconsin over the last 20 years, from 1,650 tons per day in 1967 to 1,000 tons per day in 1987.

Aspen removals have been gaining an average of 2 percent per year since 1983. This shows the strength of the aspen market, which has overcome the recent closings of two pulp mills in Wisconsin that used predominantly aspen. Strong gains have been posted for basswood,

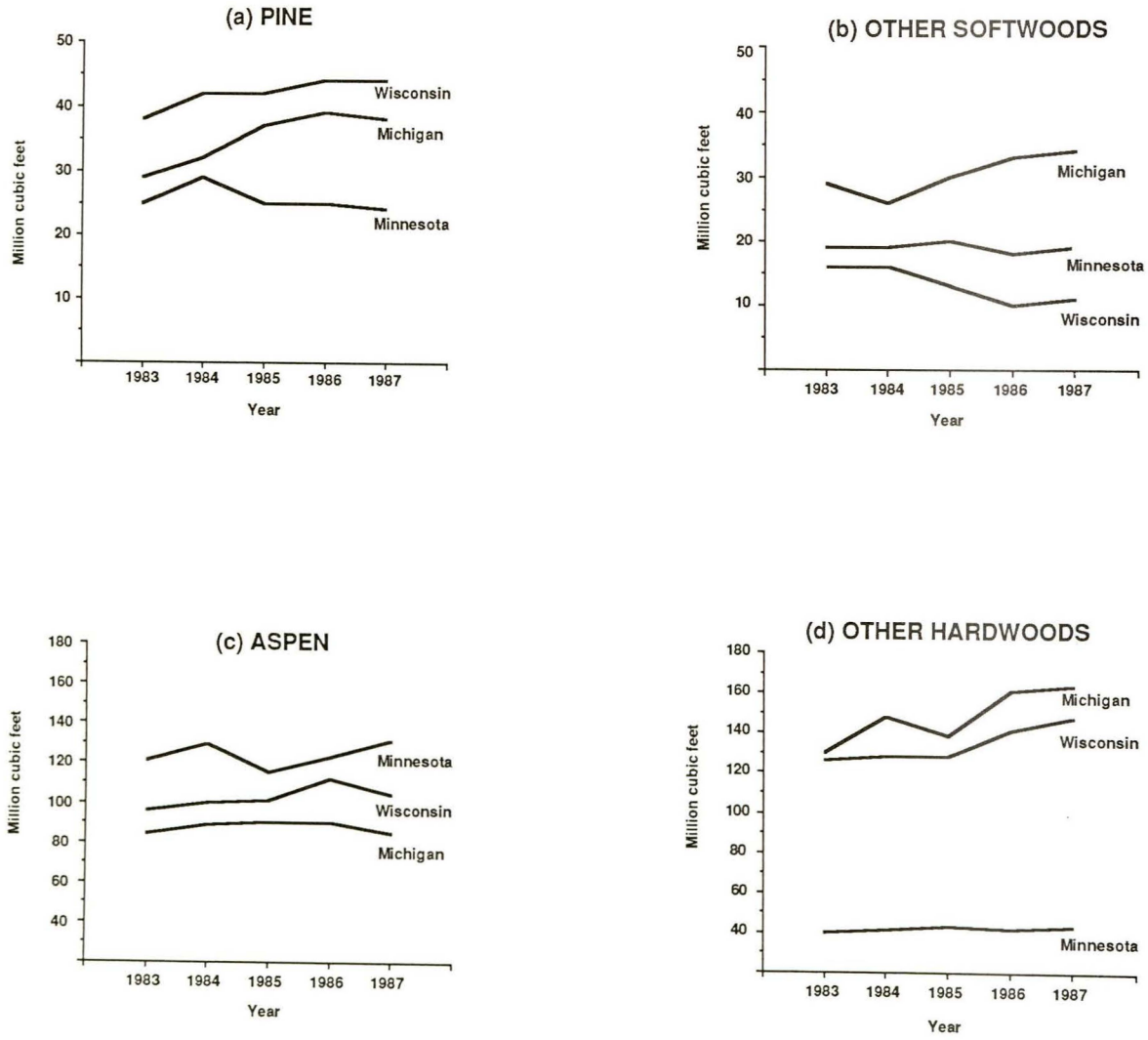

Figure 2.--*Trends in growing-stock removals for products by major species groups, 1983-1987.*

birch, and maple in Wisconsin as new pulping technology improves markets for these underutilized species.

Minnesota Aspen Rebounds

Since the aspen boom in 1982-1983, Minnesota has had a steady growth rate of 7 percent per year for aspen markets. One major setback in 1985 (11-percent decline) occurred when a large aspen-using mill closed at International Falls, but the 7-percent upward trend resumed for 1986 and 1987. Although paper birch in the non-aspen hardwood market has made strong gains, it is still considered an underused species in Minnesota. Based on recent growth figures (Hahn and Smith 1987), nearly all hardwood species in Minnesota (except aspen and oak) could sustain a significant increase in annual removals. These species have been harvested in Minnesota at a rate 50 percent lower than in Wisconsin and Michigan, relative to estimated 1987 standing inventories.

Softwood markets have been mixed in Minnesota since 1983. While red pine removals have remained steady, jack pine and white pine have dropped an average of 4 percent per year. Much of the jack pine loss can be attributed to increasing strain on an overcut resource as markets realign after the loss of many jack pine acres in the Boundary Waters legislation of 1978. Although the figures in this report are not dramatic, the outlook for spruce and fir has improved with the addition of a new softwood-oriented pulp mill in Duluth in 1987 and the recent expansion at Blandin's mill in Grand Rapids. The markets for other softwoods such as cedar and tamarack have been declining for several years, and the near future will remain bleak unless new markets develop.

Lake States Outlook is Good

Since 1983 hardwood markets have increased 50 percent faster than softwood markets in the region, which reflects the impact of emerging hardwood technologies in the area of pulp and board products. Much of the new technology is cashing in on previously underutilized hardwood species. New and expanding pulp mills that rely primarily on hardwoods other than aspen should continue improving hardwood markets in the region.

In general, aspen markets appear to be taking a breather as existing and potential users re-evaluate the ebb and flow of the inventory and its impact on logistically and economically available supplies. As harvesting pressure mounts for red oak, more and more concern will be voiced about intensive management of this valuable species.

The new pulp mill in Duluth should also improve markets for spruce and fir in northeastern Minnesota and the surrounding area. Chip-and-saw operations in Michigan have already opened new markets for red pine in that State and promise similar returns for Wisconsin and perhaps Minnesota. Outside of northeast Minnesota, the future of softwoods other than pine remains uncertain without new or expanding markets.

As industrial capacity continues to expand, growing-stock removals for products should reach 1 billion cubic feet annually in the Lake States by 1990.

Several major plant openings, expansions, and closings have shaped Lake States timber markets in the last 5 years:

Year	Activity	Primary species
Capacity increase		
1983	Flakeboard mill opens, Cook, MN	Aspen
1985	Flakeboard mill opens, Two Harbors, MN	Aspen
1985	Board mill opens, Newberry, MI	Hardwoods
1985	Chip-and-saw mill opens, McBain, MI	Red pine
1985	Pulp mill expansion, Quinnesec, MI	Mixed
1986	Pulp mill expansion, Ontonagon, MI	Mixed
1987	Pulp mill opens, Duluth, MN	Spruce-fir
1987	Veneer mill opens, Hibbing, MN	Mixed
1987	Flakeboard mill opens, Sagola, MI	Aspen
Capacity decrease		
1983	Pulp mill closes, Appleton, WI	Softwoods
1984	Pulp mill closes, Rhinelander, WI	Softwoods
1985	Pulp mill closes, International Falls, MN	Aspen
1985	Pulp mill closes, Green Bay, WI	Aspen
1986	Pulp mill closes, Tomahawk, WI	Aspen

Woodpulp Still Dominant Product

The overall drain of growing stock from timberland for products in the Lake States in 1987 breaks down this way: pulpwood (59 percent); saw logs, veneer, and miscellaneous products (32 percent); and fuelwood (9 percent) (table 1). If we

Table 1.--*Growing-stock removals from timberland for products, 1975 and 1987*

Product class	1975 removals	1987 removals	1975 share	1987 share	Volume change
	- - - Million cubic feet - - -		*- - - - - - - - - Percent- - - - - - - - -*		
Pulp	273	497	57	59	82
Saw logs & misc. products	178	273	38	32	53
Fuelwood	24	75	5	9	214
Total	475	845	100	100	72

look at total removals (including nongrowing stock), fuelwood would comprise a much higher proportion because so much of it comes from nongrowing stock sources such as dead or cull trees, noncommercial species, and lands not classed as timberland.

Potential to Double Removals

Growth is frequently used to gauge the potential for removals. Current growth in the Lakes States averages 38 cubic feet per acre per year (table 2). According to our most recent inventories, the potential for timberland in the Lake states is 62 cubic feet per acre per year. The potential is highest in Wisconsin at an average growth rate of 67 cubic feet per acre per year, followed by Michigan at 64 cubic feet and Minnesota at 58 cubic feet. Site potential is technically defined as the annual cubic foot growth per acre at culmination of mean annual increment. More simply stated it may be thought of as an estimate of the potential average annual growth of a stand between establishment and rotation. This generalization is true only if maximum fiber production is the primary goal (i.e. pulp is the dominant product). Given the mix of products in the Lake States along with diverse owner objectives and political factors, perhaps only 80 percent of this potential is realistically achievable. These figures are based on estimates for natural stands and do not reflect increases that might be realized through fertilization or the use of genetically improved stock.

Table 2.— *Site potential, achievable site, and current growth and removals*

State	Site potential	Average achievable site	1986 growth	1987 removal	Growth as percent of achievable
	- - - - - - - - - - - Cubic feet/acre/year- - - - - - - - - - -				
MN	58	46	32	16	70
WI	67	54	39	20	72
MI	64	51	41	18	80

Based upon estimates of achievable site and current growth and removal rates, the potential exists to double removals throughout the region (table 2). Two major determinants in the success of this scenario will be increased timber utilization and increased timber growth. Utilization technology must increase the use of materials such as tree tops and limbs, cull and salvable dead trees, and previously underused species. Alternatives for increasing timber growth include regeneration of poorly stocked timberland, improved and timely silvicultural practices, and intensification of timber management through fertilization and genetically improved stock.

As pointed out earlier, however, some species are under tremendous harvesting pressure already. Projections from the 1990 Assessment indicate a doubling of timber demand in the region by the year 2040. The long-term goal should be a balanced use of the forest to maintain a diversity of species and products as well as non-timber opportunities. As harvesting increases, however, we must be prepared to face increasing social and political pressure regarding our husbandry of the timber resource and its impact on the overall environment. Recent litigations of the National Forest management plans in the region must be viewed as a bellweather for mitigating factors in the further expansion of timber markets in the Lake States.

Clearly forest management must take a new direction if recent RPA projections are correct. Issues raised by the Assessment will be the focus of much research and creative thinking that will provide cooperative opportunities for university, industry, and government agencies throughout the region in the years to come. Funding for research and intensified management will also require some creative thinking as society makes increasing demands on budget dollars. A unique proposal in Michigan to encourage private funding for management of public lands could prove to be a piece of landmark legislation if successful.[1]

[1]*Forest Development Fund: An investment oriented funding arrangement for Michigan's State Forest System. Staff paper by Michigan Department of Natural Resources Forest Management Division, Michigan Department of Treasury, and Cabinet Council for Jobs and Economic Development. November, 1987.*

Through major efforts to enhance timber management and utilization adequate timber supplies can be provided from fewer acres while pressure is relieved on a natural resource from which we draw so many other non-timber commodities such as fishing, hunting, wildlife observation, recreation, and esthetic value.

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APPENDIX

Metric Equivalent of Units Used in This Report

1 acre = 4,046.86 square meters or 0.405 hectare.
1,000 acres = 405 hectares.
1 cubic foot = 0.0283 cubic meter.
1 foot = 30.48 centimeters or 0.3048 meter.
1 inch = 25.4 millimeters, 2.54 centimeters, or 0.0254 meter.

Tree Species Groups in the Lake States[2]

Softwoods
- Eastern white pine ..... *Pinus strobus*
- Red pine ..... *Pinus resinosa*
- Jack pine ..... *Pinus banksiana*
- White spruce ..... *Picea glauca*
- Black spruce ..... *Picea mariana*
- Balsam fir ..... *Abies balsamea*
- Tamarack ..... *Larix laricina*
- Hemlock ..... *Tsuga canadensis*
- Northern white-cedar ..... *Thuja occidentalis*
- Other softwoods
  - Norway spruce ..... *Picea abies*
  - Eastern redcedar ..... *Juniperis virginiana*
  - Engelmann spruce ..... *Picea engelmannii*
  - Scotch pine ..... *Pinus sylvestris*

Hardwoods
- White oak
  - White oak ..... *Quercus alba*
  - Swamp white oak ..... *Quercus bicolor*
  - Bur oak ..... *Quercus macrocarpa*
  - Chinkapin oak ..... *Quercus muehlenbergii*
  - Chestnut oak ..... *Quercus prinus*
- Red oak
  - Northern red oak ..... *Quercus rubra*
  - Scarlet oak ..... *Quercus coccinea*
  - Northern pin oak ..... *Quercus ellipsoidalis*
  - Pin oak ..... *Quercus palustris*
  - Black oak ..... *Quercus velutina*
- Hickory
  - Shagbark hickory ..... *Carya ovata*
  - Pignut hickory ..... *Carya glabra*
  - Bitternut hickory ..... *Carya cordiformis*
- Hard maple
  - Sugar maple ..... *Acer saccharum*
  - Black maple ..... *Acer nigrum*
- Soft maple
  - Red maple ..... *Acer rubrum*
  - Silver maple ..... *Acer saccharinum*
- American beech ..... *Fagus grandifolia*
- Yellow birch ..... *Betula alleghaniensis*
- Ash
  - Black ash ..... *Fraxinus nigra*
  - White ash ..... *Fraxinus americana*
  - Green ash ..... *Fraxinus pennsylvanica*
- Balsam poplar ..... *Populus balsamifera*
- Eastern cottonwood ..... *Populus deltoides*
- Black willow ..... *Salix nigra*
- Bigtooth aspen ..... *Populus grandidentata*
- Quaking aspen ..... *Populus tremuloides*
- Basswood ..... *Tilia americana*
- Black walnut ..... *Juglans nigra*
- Black cherry ..... *Prunus serotina*
- Butternut ..... *Juglans cinerea*
- Elm
  - American elm ..... *Ulmus americana*
  - Slippery elm ..... *Ulmus rubra*

[2] *The common and scientific names are based on: Little, Elbert L., 1982.*

Rock elm ..... *Ulmus thomasii*
Paper birch ..... *Betula papyrifera*
Other hardwoods
Boxelder ..... *Acer negundo*
River birch ..... *Betula nigra*
Sweet birch ..... *Betula lenta*
Sycamore ..... *Plantanus occidentalis*
Ohio buckeye ..... *Aesculus glabra*
Honey locust ..... *Gleditsia tryacanthos*
Black locust ..... *Robinia pseudoacacia*
Red mulberry ..... *Morus rubra*
American chestnut ..... *Castanea dentata*
Northern catalpa ..... *Catalpa speciosa*

Definition of Terms

Commercial species.—Tree species presently or prospectively suitable for industrial wood products. (Note: Excludes species of typically small size, poor form, or inferior quality such as hophornbeam and hawthorn.)

Forest land.—Land at least 16.7 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. (Note: Stocking is measured by comparison of basal area and/or number of trees, by age or size and spacing with specified standards.) The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, or other bodies of water or clearings in forest areas shall be classed as forest if less than 120 feet wide.

Growing-stock trees.—Live trees of commercial species qualifying as acceptable trees. (Note: Excludes rough, rotten, and dead trees.)

Growing-stock volume.—Net volume in cubic feet of growing-stock trees 5 inches d.b.h. and over, from a 1-foot stump to a minimum 4 inch top diameter outside bark of the central stem. Cubic feet can be converted to cords by dividing by 79 cubic feet per solid wood cord.

Hardwoods.—Dicotyledonous trees, usually broad-leaved and deciduous.

Mortality.—The volume of sound wood in growing-stock and sawtimber trees that die annually.

Net annual growth of growing-stock.—The annual change in volume of sound wood in live sawtimber and poletimber trees and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes.

Net volume.—Gross volume less deductions for rot, sweep, or other defect affecting use for timber products.

Noncommercial species.—Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Other removals.—Growing-stock trees removed but not utilized for products, or trees left standing but "removed" from the timberland classification by land use change. Examples are removals from cultural operations such as timber stand improvement work, land clearing, and changes in land use.

Reserved forest land.—Forest land sufficiently productive to qualify as timberland but withdrawn from timber utilization through statute, administrative regulation, designation, or exclusive use for Christmas tree production, as indicated by annual shearing.

Rotten trees.—Live trees of commercial species that do not contain at least one 12-foot saw log or two saw logs 8 feet or longer, now or prospectively, and/or do not meet regional specifications for freedom from defect primarily because of rot; that is, when more than 50 percent of extra cull volume in a tree is rotten.

Rough trees.—(a) Live trees of commercial species that do not contain at least one merchantable 12-foot saw log or two saw logs 8 feet or longer, now or prospectively, and/or do not meet regional specifications for freedom from defect primarily because of roughness or poor form, and (b) all live trees of noncommercial species.

Saw log.—A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight and with a minimum diameter outside bark (d.o.b.) for softwoods of 7 inches (9 inches for hardwoods) or other combinations of size and defect specified by regional standards.

Site class.—A classification of forest land in terms of inherent capacity to grow crops of industrial wood based on fully stocked natural stands.

Softwoods.—Coniferous trees, usually evergreen, having needles or scale-like leaves.

Timber removals from growing stock.—The volume of sound wood in live sawtimber and poletimber trees removed annually for forest products (including roundwood products and logging residues) and for other removals. Roundwood products are logs, bolts, or other round sections cut from trees. Logging residues are the unused portions of cut trees plus unused trees killed by logging. Other removals are growing-stock trees removed by cultural operations such as timber stand improvement work, and by land clearing and changes in land use.

Timberland.—Forest land producing or capable of producing crops of industrial wood and not withdrawn from timber utilization. (Note: Areas qualifying as timberland are capable of producing more than 20 cubic feet per acre per year of annual growth under management. Currently inaccessible and inoperable areas are included, except when the areas involved are small and unlikely to become suitable for producing industrial wood in the foreseeable future.)

Table 3.-- *Estimated growing-stock removals from timberland for products by species group, Lake States, 1983-1987*

Species group	Year					Change since 1983
	1983	1984	1985	1986	1987	
	thousand cubic feet					*percent*
Jack pine	40,033	46,204	46,368	47,797	45,706	14.2
Red pine	35,698	40,820	43,862	46,453	45,993	28.8
White pine	16,420	16,764	14,089	14,262	14,491	-11.7
Spruce	17,901	20,560	19,839	19,375	20,399	14.0
Balsam fir	24,188	25,898	24,115	21,082	22,069	-8.8
Hemlock	8,590	7,320	6,605	7,080	7,261	-15.5
Tamarack	3,182	2,123	1,272	1,597	2,676	-15.9
Northern white-cedar	10,673	8,841	11,341	12,087	11,993	12.4
Total	156,685	168,530	167,491	169,733	170,588	8.9
White oak	18,502	19,406	20,264	20,619	21,142	14.3
Red oak	72,779	81,329	84,616	86,091	87,175	19.8
Hickory	1,259	1,266	1,328	1,315	1,359	7.9
Basswood	13,362	14,229	15,048	17,162	17,640	32.0
Beech	6,604	7,414	6,179	6,879	7,871	19.2
Yellow birch	6,856	7,528	7,805	9,788	10,023	46.2
Hard maple	53,879	60,141	58,570	67,021	71,114	32.0
Soft maple	32,517	35,550	36,164	44,218	45,507	39.9
Elm	24,705	23,685	15,716	15,388	13,661	-44.7
Ash	15,501	15,436	16,027	16,731	17,726	14.4
Cottonwood	2,102	1,973	2,116	2,098	2,134	1.5
Balsam poplar	8,907	8,471	6,738	6,351	5,937	-33.3
Aspen	299,640	318,716	306,405	324,468	320,493	7.0
Paper birch	35,001	35,719	33,991	45,738	47,009	34.3
Black walnut	381	392	350	349	365	-4.2
Other hardwoods	4,590	4,970	4,229	4,827	5,134	11.9
Total	596,585	636,225	615,546	669,043	674,290	13.0
All species	753,270	804,755	783,037	838,776	844,878	12.2

Table 4.-- *Estimated growing-stock removals from timberland for products by species group, Minnesota, 1983-1987*

Species group	Year					Change since 1983
	1983	1984	1985	1986	1987	
	thousand cubic feet					*percent*
Jack pine	13,401	14,715	12,696	11,961	11,078	-17.3
Red pine	7,405	10,992	9,580	10,016	9,653	30.4
White pine	3,756	3,525	2,793	3,037	2,915	-22.4
Spruce	7,812	9,468	8,954	7,980	8,218	5.2
Balsam fir	7,795	11,612	9,789	8,193	9,088	16.6
Hemlock	0	0	0	0	0	0.0
Tamarack	2,118	1,009	819	1,114	778	-63.3
Northern white-cedar	1,470	808	791	782	821	-44.1
Total	43,757	52,129	45,422	43,083	42,551	-2.8
White oak	2,332	2,260	2,452	2,401	2,464	5.7
Red oak	8,762	11,647	12,984	12,759	13,197	50.6
Hickory	41	30	31	29	29	-29.3
Basswood	1,789	1,660	1,917	1,893	1,976	10.5
Beech	0	0	0	0	0	0.0
Yellow birch	68	33	33	33	33	-51.5
Hard maple	1,053	1,022	1,060	1,014	1,024	-2.8
Soft maple	680	661	694	665	672	-1.2
Elm	5,864	4,028	4,338	4,233	4,336	-26.1
Ash	4,692	3,771	3,991	3,883	3,954	-15.7
Cottonwood	1,162	1,026	1,169	1,151	1,199	3.2
Balsam poplar	5,343	4,914	3,907	3,810	3,450	-35.4
Aspen	120,577	129,166	115,266	122,811	131,454	9.0
Paper birch	8,301	9,255	9,843	10,274	10,710	29.0
Black walnut	51	36	43	43	45	-11.8
Other hardwoods	312	296	298	290	291	-6.7
Total	161,027	169,805	158,026	165,289	174,834	8.6
All species	204,784	221,934	203,448	208,372	217,385	6.2

Table 5.-- *Estimated growing-stock removals from timberland for products by species group, Wisconsin, 1983-1987*

Species group	Year					Change since 1983
	1983	1984	1985	1986	1987	
	thousand cubic feet					*percent*
Jack pine	13,976	15,666	15,703	17,648	16,583	18.7
Red pine	16,737	19,216	19,646	20,680	21,061	25.8
White pine	7,384	7,499	6,582	6,160	6,681	-9.5
Spruce	2,643	3,640	2,789	2,360	2,767	4.7
Balsam fir	7,221	6,865	5,475	3,547	3,485	-51.7
Hemlock	4,192	3,056	3,276	3,259	3,667	-12.5
Tamarack	472	312	137	148	142	-69.9
Northern white-cedar	1,765	1,678	1,169	1,102	1,157	-34.4
Total	54,390	57,932	54,777	54,904	55,543	2.1
White oak	10,008	10,028	9,760	9,865	10,448	4.4
Red oak	37,031	36,705	41,329	42,892	43,596	17.7
Hickory	636	619	572	577	593	-6.8
Basswood	6,120	6,226	6,997	7,837	8,055	31.6
Beech	602	652	368	364	406	-32.6
Yellow birch	2,474	2,471	2,664	2,842	3,159	27.7
Hard maple	21,747	22,414	24,698	27,552	29,471	35.5
Soft maple	11,070	11,930	12,715	14,049	16,086	45.3
Elm	13,257	13,172	6,490	6,040	5,559	-58.1
Ash	5,691	5,728	5,430	6,044	6,491	14.1
Cottonwood	271	273	137	139	145	-46.5
Balsam poplar	251	302	215	145	132	-47.4
Aspen	95,534	100,227	101,210	111,612	104,245	9.1
Paper birch	15,633	16,296	15,714	21,821	21,835	39.7
Black walnut	161	161	158	159	166	3.1
Other hardwoods	1,458	1,431	878	1,033	1,042	-28.5
Total	221,944	228,635	229,335	252,971	251,429	13.3
All species	276,334	286,567	284,112	307,875	306,972	11.1

Table 6.-- *Estimated growing-stock removals from timberland for products by species group, Michigan, 1983-1987*

Species group	Year					Change since 1983
	1983	1984	1985	1986	1987	
	thousand cubic feet					*percent*
Jack pine	12,656	15,823	17,969	18,188	18,045	42.6
Red pine	11,556	10,612	14,636	15,757	15,279	32.2
White pine	5,280	5,740	4,714	5,065	4,895	-7.3
Spruce	7,446	7,452	8,096	9,035	9,414	26.4
Balsam fir	9,172	7,421	8,851	9,342	9,496	3.5
Hemlock	4,398	4,264	3,329	3,821	3,594	-18.3
Tamarack	592	802	316	335	1,756	196.6
Northern white-cedar	7,438	6,355	9,381	10,203	10,015	34.6
Total	58,538	58,469	67,292	71,746	72,494	23.8
White oak	6,162	7,118	8,052	8,353	8,230	33.6
Red oak	26,986	32,977	30,303	30,440	30,382	12.6
Hickory	582	617	725	709	737	26.6
Basswood	5,453	6,343	6,134	7,432	7,609	39.5
Beech	6,002	6,762	5,811	6,515	7,465	24.4
Yellow birch	4,314	5,024	5,108	6,913	6,831	58.3
Hard maple	31,079	36,705	32,812	38,455	40,619	30.7
Soft maple	20,767	22,959	22,755	29,504	28,749	38.4
Elm	5,584	6,485	4,888	5,115	3,766	-32.6
Ash	5,118	5,937	6,606	6,804	7,281	42.3
Cottonwood	669	674	810	808	790	18.1
Balsam poplar	3,313	3,255	2,616	2,396	2,355	-28.9
Aspen	83,529	89,323	89,929	90,045	84,794	1.5
Paper birch	11,067	10,168	8,434	13,643	14,464	30.7
Black walnut	169	195	149	147	154	-8.9
Other hardwoods	2,820	3,243	3,053	3,504	3,801	34.8
Total	213,614	237,785	228,185	250,783	248,027	16.1
All species	272,152	296,254	295,477	322,529	320,521	17.8

Table 7.-- *Factors to convert volume of primary product receipts to volume of growing stock removed from timberland by species and major product, Minnesota*

Species	Pulpwood	Saw logs and miscellaneous products	Fuelwood [1]
Jack pine	0.95	0.99	0.10
Red pine	0.94	0.98	0.10
White pine	0.94	1.02	0.10
Spruce	0.97	0.99	0.10
Balsam fir	0.97	1.00	0.10
Tamarack	0.97	1.00	0.28
Northern white-cedar	1.00	0.93	0.10
White oak	1.00	1.12	0.15
Red oak	1.05	1.11	0.18
Basswood	1.00	1.15	0.22
Yellow birch	1.00	1.00	0.22
Hard maple	1.08	1.11	0.26
Soft maple	1.08	1.20	0.23
Elm	0.95	1.14	0.22
Ash	1.00	1.16	0.24
Cottonwood	1.00	1.15	0.22
Balsam poplar	0.95	1.14	0.22
Aspen	0.91	1.02	0.27
Paper birch	0.95	1.15	0.22
Other hardwoods	0.93	1.00	0.22

1 Based on data from Wisconsin and Michigan studies.

Table 8.-- *Factors to convert volume of primary product receipts to volume of growing stock removed from timberland by species and major product, Wisconsin*

Species	Pulpwood	Saw logs and miscellaneous products	Fuelwood
Jack pine	0.81	1.06	0.10
Red pine	0.88	1.03	0.02
White pine	0.89	1.03	0.04
Spruce	0.93	1.06	0.10
Balsam fir	0.93	1.05	0.09
Hemlock	0.89	1.04	0.02
Tamarack	0.97	1.00	0.28
Northern white-cedar	0.86	1.05	0.02
White oak	0.84	1.08	0.15
Red oak	0.83	1.08	0.18
Hickory	0.64	0.99	0.19
Basswood	0.63	0.98	0.12
Beech	0.65	0.99	0.20
Yellow Birch	0.63	0.99	0.22
Hard maple	0.86	1.04	0.26
Soft maple	0.81	0.98	0.23
Elm	0.63	0.98	0.07
Ash	0.63	0.98	0.24
Cottonwood	0.86	1.02	0.03
Balsam polpar	0.63	1.00	0.08
Aspen	0.95	1.10	0.22
Paper birch	0.89	0.98	0.21
Other hardwoods	0.64	1.01	0.05

Table 9.-- *Factors to convert volume of primary product receipts to volume of growing stock removed from timberland by species and major product, Michigan*

Species	Pulpwood	Saw logs and miscellaneous products	Fuelwood
Jack pine	0.90	1.06	0.59
Red pine	0.87	1.04	0.54
White pine	0.87	1.02	0.53
Spruce	1.00	1.06	0.58
Balsam fir	1.00	1.05	0.54
Hemlock	1.00	1.02	0.55
Tamarack	1.00	1.06	0.63
Northern white-cedar	1.00	1.05	0.62
White oak	0.82	1.04	0.25
Red oak	0.82	1.04	0.26
Hickory	0.64	1.09	0.28
Basswood	0.88	1.13	0.35
Beech	0.68	1.08	0.33
Yellow Birch	0.67	1.09	0.41
Hard maple	0.70	1.11	0.37
Soft maple	0.88	1.13	0.32
Elm	0.89	1.13	0.15
Ash	0.88	1.14	0.35
Cottonwood	0.88	1.14	0.03
Balsam polpar	0.88	1.14	0.23
Aspen	0.94	1.07	0.27
Paper birch	0.88	1.14	0.37
Other hardwoods	0.89	1.14	0.12

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Growing-stock removals for products have increased by 12 percent in the Lake States since 1983. Regional gains are led by red pine, aspen, and other hardwoods. New mills and technology promise to further improve markets for underutilized species throughout the region.

KEY WORDS: Growing-stock removals, forest products, timberland.

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.